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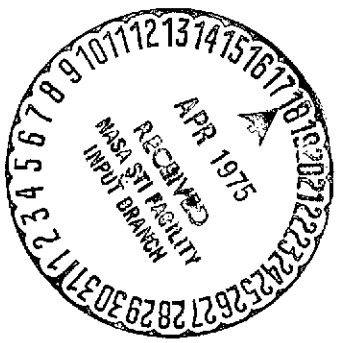


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PROGRESS

# SPACE RESEARCH AND SCIENTIFIC-TECHNOLOGICAL PROGRESS

B.I. Petrov

Space research and the conquest of outer space is one of /36* the most important developments of the contemporary scientific-technological revolution and one of the most outstanding achievements of human genius. The penetration of man into space is a natural and logical step in world progress. Following the exploration of the surface of the earth, the ocean depths, and the atmosphere, it was inevitable that mankind should begin the exploration of space, the environment which until recently was still unknown, and in which our planet was born, moves and has its being. This environment, together with the celestial bodies distributed in it, plays no less a role than the oceans and the atmosphere in the life of mankind and all living things, and its study and exploration will exert enormous influence on the development of terrestrial civilization.

Space research is of great scientific and cognitive value. It enriches physics, cosmology, geophysics, aeronomy, meteorology and biology with new discoveries and new scientific results and provides invaluable material concerning the structure of outer space near the earth, concerning the moon and the nearest planets, concerning processes taking place in the atmosphere of the earth and their relationship to solar activities, and concerning the structure of matter. These new facts make more precise, and sometimes radically change, our conception of the ma-

* Numbers in the margin indicate pagination of original foreign text.

terial world surrounding us.

In the epoch of space explorations, new directions for science have been formulated, and existing scientific disciplines must be supplemented by new striking discoveries. Among the foremost fields of contemporary science, one can name the mechanics of space flight, the theory of rocket engines, the theory of aircraft control, space radioelectronics, space physics, space meteorology and aeronomy and many others.

The solution of new fundamental questions of modern physics is linked to an investigation of space. For example, the study of cosmic rays has tremendous significance for the development of nuclear physics. The search for new elementary particles, the acquisition of new nuclear reactions, and especially the study of particles of high and ultra-high energy is related to the investigation of cosmic rays. As is well-known, primary cosmic rays practically never reach the surface of the earth; hence the study of cosmic rays with the aid of satellites and other space apparatus is of enormous significance.

It is difficult to overestimate the importance of astrophysical and radiophysical investigations for the solution of many important problems of contemporary physics. The discovery of quasars and pulsars, these powerful cosmic sources of radio emissions, the investigations of supernova stars pose entirely new puzzles for physicists. The study of these objects with the aid of astrophysical stations outside the atmosphere, and other means of space investigations, opens up large perspectives in the treatment of the most important problems of contemporary physics, which are of great scientific and philosophical significance. /37

The epoch of space exploration using indirect study of in-

terplanetary cosmic space, the Moon and the nearest planets, methods of extra-atmospheric astronomy, the investigation of the earth and its atmosphere from outer space - this is a new step in the development of science generally, a qualitatively new step in the research of man, in the development of methods and means of knowing nature. This epoch represents the most extensive development of the dialectic-materialistic theory of knowledge, the strengthening of the principles of Marxist philosophy and the materialistic explanation of the world around us.

New discoveries which have not yet been fully explained, new puzzles of nature, evoke more intensive research for means of studying them, and lead to the creation of new methods and ways of research, to the subsequent development of the dialectic-materialistic knowledge of the structure of matter and the universe, and bring us to a more complete disclosure of the secrets of nature. Here one may recall the well-known dictum of V.I. Lenin: "In the theory of knowledge, as in all other realms of science, one should think dialectically, i.e., one should not assume our knowledge to be finished and unchanging, but analyze in what manner from ignorance knowledge appears, how incomplete, imprecise knowledge becomes more complete and more precise." [1]

The investigations within the various trends of science whose goal is a knowledge of the universe, its structure and the processes taking place within it, and the cosmic bodies distributed in it - this is one of the broadest spheres of research activity of man where the dialectic process of knowledge is very fruitful and has already provided many brilliant results. Within a short period, space explorations have enriched science with many outstanding discoveries in the study of the Moon and the nearest planets, making it possible to learn much that is new about our Earth as an object in space. They made possible the penetration of man into a new environment and the start of his

practical activity in these new unusual conditions.

In the initial period of the conquest of space, the leading space powers - the USSR and the USA - directed their energies to the solution of similar problems (obtaining primary information about celestial bodies, working out various technical devices for flights to the Moon and to far space). Having accumulated the necessary experience in the solution of problems of cosmonautics, having created a powerful technology, the leading space powers are going their own way in the further exploration of space. This process is understandable and natural. The circle of cosmic objects accessible for study has been significantly enlarged.

Scientists usually propose far more problems than can be financed in a given period of time, and space explorations are expensive. Therefore, it is important to determine in the best way the strategic goal, to choose that upon which one must concentrate in the first instance, what must be given preference. It is necessary to establish a hierarchy of goals and tasks. However, on the other hand, it is difficult at times to foresee exactly which course will produce the maximum scientific and practical effect. Therefore, a space program must be flexible and comprehensive, must provide for a broad search for new ideas in fields which are entirely unexplored. Here one must not forget that, in order to achieve certain goals, rocket-space complexes and apparatus are necessary which are sufficiently reliable and economically justifiable.

The goals of the Soviet space program are determined by the /38
demands of science, the national economy, by the demands of scientific-technological progress. Systematically and stepwise it embraces various fields of research and space exploration.

In our country at the present time space exploration is developing in three basic directions: investigation of outer space near the earth with the help of geophysical rockets, satellites and spacecraft; investigation of the Moon and the planets; medico-biological research and manned flights into outer space.

In the study of the outer space of the Moon and other bodies of the solar system, the leading role in our country at present is assigned to automatic apparatus. For many years to come, they will remain practically the sole instrument for the study of far space and the planets. However, while valuing highly the usefulness of automatic machines, one must nonetheless not be guilty of absolutism with regard to their value and possibilities in space. Such machines cannot replace man in everything. An astronaut while on board an orbiting spacecraft not only discovers natural phenomena of interest to us ("the eye of a typhoon", the focus of a forest fire, etc.), but also directs toward them equipment and instruments, and makes the necessary decisions. For the time being, there are much fewer piloted flights than launchings of automatic machines, but their value is enormous. The arena of the present stage of development of the Soviet outer space program of piloted flights is space near the Earth. Here are sent the piloted spacecrafts and systems intended for scientific research, transport vehicles, orbiting stations with a long life expectancy. The direct participation of man has the greatest effectiveness in the study of space near the earth, in the conduct of observations having national economic value, of course, in conjunction with the use of automatic equipment.

If in the first years of space exploration it was proved that it is possible for man to fly into outer space and to work in it, then the problem now is a systematically planned research effort by man with the aid of orbiting space laboratories. Still larger, universal space research laboratories and specialized

stations will be built, e.g. astronomical, astrophysical, radio-astronomical orbiting stations outside the atmosphere. Such observatories can be constructed both in a completely automatic variant and also in a variant with periodic visits by their personnel without the continuous presence of a crew on board.

In recent years the Soviet explorers of space have achieved noteworthy successes. Thus the pilot-cosmonauts of the USSR, V.G. Lazarev and O.G. Makarov, completed a flight on board the spacecraft "Soyuz-12" and carried out a series of scientific and scientific-technological experiments. They conducted spectography of natural formations which were of great interest for developing methods of studying the Earth from outer space. At the same time they carried out tests of the improved flight systems of the spacecraft.

A crew consisting of pilot-cosmonauts of the USSR, P.I. Klimuk and V.V. Lebedev, completed a space flight on the spacecraft "Soyuz-13". An important result obtained by the cosmonauts in the course of the flight was the multizonal photography of individual portions of the terrestrial surface simultaneously in ten narrow spectral zones situated within the limits of the visible and short-range infrared band. For the study of natural resources, such photographs offer much more than usual color photography.

On "Soyuz-13" biological experiments were set up. With the aid of the device "Oazis-2", tests were conducted which are connected with certain principles of a closed ecological system with regeneration, i.e., with regeneration of human vital products. /39

Scientific data of great value were yielded by spectography of stars in the ultraviolet band with the aid of the system of telescopes "Orion-2" which was established on the spacecraft.

As is well known, observations in this band can only be carried out outside the limits of the atmosphere, since the atmosphere completely absorbs the short wave part of the spectrum. The cosmonauts obtained and delivered to the Earth several thousand spectrograms of nearly 3000 stars, among them unique spectrograms of weak stars up to the 11th and even the 12th magnitude. For comparison it should be recalled that with the naked eye one can see only stars no weaker than the 5th-6th magnitude. The spectrograms allow one to determine what chemical elements enter into the composition of stars. Indeed, the spectral lines of many elements are related to the ultraviolet region.

The experimental results obtained make a great contribution to astrophysics and provide new material for studying the stars which are at various stages of evolution; they shed new light on the processes of evolution of the universe.

A broad complex of investigations were conducted by the pilot-cosmonauts, P.R. Popovich and Yu.P. Artyukhin, on board the orbiting station "Salyut-3" to which they were delivered by the spacecraft "Soyuz-14". "Salyut-3" can be both manned or unmanned. The cosmonauts carried out tests of the improved flight systems of the station, the life support system, they conducted medico-biological experiments with the help of the multi-functional apparatus "POLINOM-2M", and a large complex of investigations of the Earth surface with an economic purpose were performed. They conducted photography of geomorphological formations, spectography of the twilight aureole of the Earth and the daytime horizon. The data obtained will be used in the solution of national economic problems and will provide new material for the development of areas, perspectives for seeking useful minerals, for the study of the condition and the prognosis of the movement of glaciers, for the evaluation of the status of forests, etc.

Scientific research and investigations in outer space which were begun with the flight of the spacecraft "Soyuz-14" and the station "Salyut-3" were continued by the pilot-cosmonauts, G.S. Sarafanov and L.S. Demin, on board the spacecraft "Soyuz-15". The cosmonauts completed scientific-technological experiments concerning piloting a spacecraft in various flight routines, maneuvering processes, and docking with the station "Salyut-3". In the course of the manuvers, the spacecraft "Soyuz-15" was repeatedly docked with the station "Salyut-3". The cosmonauts controlled the operation of all systems of the spacecraft, made observations of the stages of docking with the station and inspected the result. They also worked out methods and means of searching for and evacuating a spacecraft, and landing under nighttime conditions.

Many problems in the study of space require complex investigations, combinations of investigations carried out with the aid of scientific apparatus installed on board satellites, automatic interplanetary stations or spacecraft, and observations and experiments conducted on the surface in various regions of the Earth. Among such problems one may mention, e.g., the study of the Sun-Earth relationship, and in particular, the influence of the short wave solar radiations on the upper atmosphere and the terrestrial ionosphere, the study of the magnetic and gravitational fields of the earth, meteorological, ionospheric and geomagnetic research in the magneto-conjugate focii of the Earth, etc.

The flights of three Soviet orbiting solar observatories /40
"Prognoz" have provided interesting results. The height of the apogee of their elliptical orbits was nearly 200,000 km, while the height of the perigee was on the order of 600 km, which ensured the operation of scientific instruments within the zone of the magnetic field of the Earth and made it possible to study

the unperturbed current of charged particles coming from our star - the "solar wind" - and also the characteristics and position of the boundaries of the terrestrial magnetosphere. Of special interest is the investigation of the dynamics of the radiation belts and the phenomena at the boundary of the magnetosphere during solar flares.

In the period of heightened solar activity, the terrestrial magnetosphere was strongly deformed. In the phase of compression, its radius in the direction toward the sun was reduced to almost one-half in comparison with its unperturbed state, and in the phase of restoration, its size was almost doubled. The periodic structure of bursts of X-rays during solar flares and other phenomena were also studied.

A complex of investigations of the lunar surface and certain astrophysical research were conducted with the aid of the scientific laboratory "Lunokhod-2", remotely controlled from the Earth. During five lunar days, traveling over a complicated topography, Lunokhod covered a path 3.5 times longer than the path traversed by the self-propelled apparatus "Lunokhod-1". These explorations were conducted on the eastern boundary of the Sea of Serenity in the crater Le Monnier - in the transitional continent zone. Special interest attaches to the investigations in the immediate vicinity of the large tectonic fault "Borozda Pryamaya" which extends from the north to the south for 16 km. More than 80,000 television shots and 86 panoramas were transmitted to the Earth, and also stereoscopic images of the most interesting details of the topography. New data concerning physico-mechanical properties of the surface layer of the lunar soil were obtained. Repeated analyses of the chemical composition of the lunar rock were carried out with the help of the improved apparatus "RIFMA-M", during which the percentile content of silicon, calcium, iron and aluminum was determined. Changes in the

chemical composition connected with various kinds of rock in the sea and the continental regions were registered. With the aid of an astrophotometer installed on the "Lunokhod-2", measurements of the brightness of the lunar sky were made at various periods of the day. An increased brightness of the sky was noted in comparison to what was expected, which in principle can be explained by a dust cloud around the moon, consisting of particles varying in size from 10 to 70 microns.

On "Lunokhod-2" there was installed a corner reflector of French manufacture for laser locating. Experiments with regard to laser locating of the Moon were conducted at the time of the stoppage of the Lunokhod in the period of the lunar night, and also after completion of the operating program of the lunar laboratory. Soviet scientists conducted more than 40 sessions of laser location. The statistical precision of the determination of the distance to the Moon amounts to 40 centimeters. Systematic measurements of the distance to our natural satellite with such a high degree of precision are of great significance both for the study of the complex motion of the Moon, and also for conducting geophysical and geodesic research. An interesting experiment on the laser location of the Lunokhod was carried out successfully with the aid of a photoreceiver of laser radiation mounted on board the Lunokhod. There was also a series of other experiments.

In February-March 1974, four automatic interplanetary stations, launched in the spring of the previous year, reached the vicinity of the planet Mars. With the help of these stations, exploration of Mars and the neighboring space was carried out from a fly-by trajectory, from the orbit of an artificial satellite of the planet and from apparatus which was lowered to the surface. Just as previously, a broad complex of studies of interplanetary space were accomplished during the flight. For

the first time, the parameters of the atmosphere of the planet Mars were directly measured in a portion of the descent of the released apparatus of the station "Mars-6" and transmitted to the Earth. /41

The automatic station "Mars-5" was placed in an elliptical orbit as a satellite of Mars with a period of rotation around the planet of approximately 25 hours. All operations for the concluding stage of the flight, among them the switching on of the retro rockets, were completed automatically with the aid of the astronavigation system on board.

The automatic stations "Mars-4", "Mars-6" and "Mars-7", on passing into the immediate neighborhood of Mars, continued flying along a heliocentric orbit and for a long time transmitted scientific information to the Earth, conducted investigations of the radio emissions of the sun, cosmic rays and various physical characteristics of cosmic space.

Photography provides much information about the morphology of the surface of Mars. The station "Mars-4" photographed Mars from a fly-by trajectory, and the station "Mars-5" did so from the orbit of an artificial satellite. The photography was carried out with the help of two photo-television devices with different objectives. This made it possible to distinguish details on the photographs with dimensions on the order 1 km and 100 meters. The color photographs were of great interest. The scanning optico-mechanical devices of the station gave a picture of the broader bands of terrain in the course of the flight.

With the photographs, a region of several thousand kilometers in the southern hemisphere was covered. On the photographs, one can distinguish many interesting details - in particular, flat-bottomed craters with accumulated sandy detritus, meandering cracks

and canyons. A number of other curious peculiarities of the surface structure of the planet were disclosed. Their analysis supplements the data obtained from the photography of the Mars stations "Mariner-9", on the basis of which American scientists have drawn conclusions about the relatively recent geological activity on Mars and the significant role of erosion processes in the formation of the topography of its surface. Certain details of the surface may be construed as the result of water erosion. This covers formations which remind one of dry river beds, the age of which, according to the estimates, does not exceed several million years. On this basis, many scientists now express the view that in the past on the surface of Mars there may have been a large quantity of water and Mars had a much denser atmosphere than at present. It is not precluded that a significant portion of the Martian atmosphere is frozen in the polar caps which consist of condensed carbon dioxide and water (ice).

At the present time, the atmospheric pressure on the surface of Mars amounts on the average to approximately 5-6 millibars, i.e. it is approximately 100 times less dense than the Earth's atmosphere. At such a pressure, liquid water cannot exist on the surface, since it all evaporates into the atmosphere. The basic component of the atmosphere of Mars is carbon dioxide gas, possibly with an appreciable admixture of inert gas (most likely, argon), very little oxygen - approximately 1.1%. The content of carbon monoxide and water vapor is of about the same order of magnitude. Measurements on the Soviet automatic stations show that the amount of water vapor in the atmosphere is different in various regions of the planet and changes according to season even in the course of a day. A photometer sensitive to the absorption lines of water vapor has recorded that its content in the atmosphere during the measurements on the station "Mars-5" was approximately 10 times greater

than in the years 1971-1972.

With the aid of the instruments of "Mars-5", a study of the physical characteristics of the planet with respect to its radiation in the broad interval of wavelengths from centimeters down to gamma rays was carried out. These experiments provided data concerning the temperature of the surface and the subsurface layer at a depth of several tens of centimeters, concerning the structure and topography of the surface, and the density of the soil. /42
Measurements of the gamma radiation promise definitive information about the character of the Martian rock.

An important consequence of the experiments which were conducted is the possibility of constructing a working model of the atmosphere of Mars. This is essential for the calculation of the aerodynamic braking and landing of future Martian apparatus. From this point of view, great interest attaches to the results of determining the atmospheric parameters during the descent of the apparatus "Mars-6".

Experiments in neighboring planetary space allow one to measure the intensity of the Martian magnetic field which exceeds by 7-10 fold the intensity of the interplanetary field carried along by the solar wind, but which is 100 times weaker than the Earth's magnetic field. This result is of great significance in understanding the internal structure and the evolution of the planet.

Diverse information obtained as a result of the flights of the automatic interplanetary stations of the type of "Luna", "Venera" and "Mars" provide much new data about the heavenly bodies nearest to the earth and are a valuable contribution to planetology.

Exploration of space - this is a field in which consolidation of the efforts of many countries turns out to be especially fruitful. The problems of the study of space are so broad and manifold that they cannot be solved by one country, however high the level of scientific and technological development which it has achieved. The participation of scientists of different countries, different schools and trends can be extremely effective in working out the problems of the exploration of space.

Scientists of various countries constantly advance new ideas for the organization of space experiments. Many of these ideas are of a global character. In this connection, space is becoming the arena of broad international collaboration and demands unification of the efforts of many countries and, of course, of countries having the greatest accomplishements in the exploration and exploitation of outer space.

The universe is a global concept. Penetration into its secrets and exploration of outer space surrounding our Earth present enormous interest for the science of all countries and point to the necessity of united effort. Joint experiments and a broad exchange of scientific information between scientists of various countries will make it possible to understand more quickly the laws governing the evolution of the universe, the influence of the processes occurring on the Sun on the atmosphere of the Earth and on all living creatures of our planet, and will expedite the practical utilization of the achievements of space technology for national economic goals. To this end - namely, while striving for the conversion of space into an arena of peace and international collaboration of governments - the USSR is implementing broad international relations in the exploration and utilization of outer space.

In our country, great attention is devoted to the development of international collaboration on the exploration and uti-

lization of outer space for peaceful purposes. "We are supporters of international collaboration in the study of space. The participation of the seven socialist countries - Bulgaria, Hungary, the German Democratic Republic, Poland, Rumania, the Soviet Union and Czechoslovakia - in the investigations conducted with the help of the artificial Earth satellite "Interkosmos-1" was an excellent experience in creative concord," said General Secretary of the Central Committee of the Communist Party of the Soviet Union, L.I. Brezhnev at a meeting in honor of the participants of a group flight of cosmonauts on the 22nd of October, 1969. /43

During recent years, great progress in the realization of the program "Interkosmos", undertaken by the socialist countries, has been achieved. Already the launching of eleven satellites of the series "Interkosmos", two geophysical rockets, "Vertikal", a large number of meteorological rockets, and the conduct of a series of complex experiments have been completed.

An international organization, "Intersputnik", created by the socialist countries, is functioning. In Mongolia a station is operating for the reception of television programs. In Cuba a station has been put into operation for the reception and transmission of programs of color television through the communication satellite "Molniya".

A major event was the launching of the satellite "Interkosmos-Kopernik-500" in 1973, which was proclaimed by UNESCO as the year of Copernicus. On board the satellite, together with Soviet instruments, there were installed scientific instruments created by Polish specialists under the supervision of scientists of the university named after Nicolas Copernicus. A radiospectrograph and ionospheric sondes from on board the satellite investigated the long-wave radiation of the Sun which is absorbed by the atmosphere and does not reach the Earth, and the charac-

teristics of the ionosphere. These experiments have made it possible to obtain new data about processes occurring on the Sun, about the influence of solar activity on the atmosphere of the Earth and were a further step in the course of studying "cosmic weather', i.e., the conditions of human flight into outer space.

A complex experiment based on launching the satellite "Interkosmos-10" was dedicated to the study of the interaction of the magnetosphere and the ionosphere. Simultaneously the upper atmosphere was sounded up to a height of 100-170 kilometers with the help of meteorological rockets on the island of Kheys and in the region of Volgograd. In these investigations ground observatories also participated. On board the satellite, instruments were installed which were created by scientists and specialists of the German Democratic Republic, the USSR and the Czechoslovakian SSR.

In this same period, in accordance with the program of collaboration with France, the satellite "Oreol-2" was launched for the study of the polar auroras, and high-level balloons were launched with scientific apparatus for the investigation of electron entry into the polar ionosphere.

A characteristic feature of all these experiments was the combining of satellite, rocket, balloon and surface methods, ensuring simultaneous "stepwise" investigation of the physical processes in neighboring space. Such complicated complex experiments characterize a new step in the development of international collaboration for the study of outer space near the Earth.

The work of Soviet and Indian specialists progressed successfully with regard to the preparations for launching the first Indian satellite with the help of a Soviet rocket-carrier from the territory of the Soviet Union.

A radioastronomical experiment regarding research on the radio emission of the Sun in the metric wave band was carried out jointly with French scientists on the automatic stations "Mars-6" and "Mars-7" with the help of a French instrument in accordance with the project "Stereo". Simultaneous recording of the solar radiation on the Earth and with the aid of this instrument at a distance of 100 million kilometers - with such an immense base - makes it possible to obtain data about the directional diagram of radiation and local solar regions where these waves are generated.

In accordance with plans, preparations are underway for a projected June 1975 flight involving the docking of Soviet and American spacecraft "Soyuz" and "Apollo" in outer space and the mutual transfer of cosmonauts. This project is being carried out on the basis of a Soviet-American intergovernmental agreement undertaken at the time of the summit meeting in Moscow on May 24, 1972. The project is an example of the collaboration of two countries when, as a result of the joint efforts of specialists, devices for docking spacecraft were developed and a common system of approach and docking the spacecraft. The project has for its object the humane goal of increasing the safety of human flights into space. /44

Collaboration with American specialists and scientists is not confined to space itself; it extends also to its use for peaceful purposes. First of all it is important for the practical aspect of the investigation of terrestrial resources with the help of space technology. The means to this end open up broad perspectives for prediction of the weather, for determining ice conditions, for the study of the condition of crops and forested areas, for the solution of many problems connected with geology, especially with the exploration of useful minerals. This new direction in the application of space technology pro-

mises enormous results in the future. The solution of such problems demands the most far-reaching improvements in space technology and instrument manufacture, the working out of problems which are closely related to the problems enumerated above: the necessity of creating new highly sensitive optical and radiometric instruments, spectrographic apparatus, the study of the influence of various factors on the optical characteristics of the surface of the Earth, etc. The given direction for the use of space technology in the interests of national economy, in the interests of economic development, is long range and requires the latest achievements of science, so that joint efforts of scientists and specialists of different countries are especially useful, and in the full sense of the words, mutually advantageous.

Recently, American scientists have obtained interesting data in the course of experiments conducted by astronauts on board the orbiting station "Sky Lab" launched last year in the USA, and also during the flight of the automatic station "Pioneer-10" toward Jupiter and "Mariner-10" flying past Venus and Mercury.

Soviet scientists react with great respect to the attainments of other countries in the exploration of outer space. Exploration of space is an international matter by its very essence. As L.I. Brezhnev has remarked, "Today, essentially all people of the terrestrial globe already enjoy the fruits of the exploration of space. It is sufficient to name such fields of science and technology as space television, long-range telephonic and telegraphic communication, the participation of spacecraft in the compilation of weather forecasts, space navigation of ocean vessels [2].

Achievement of the Soviet program of exploration of outer

space with the help of manned spacecraft and orbiting stations, artificial satellites of the Earth and automatic interplanetary stations designed for the investigation of the Moon and the planets of the solar system - Mars, Venus - have made it possible for Soviet scientists to advance in the study of outer space in knowledge about laws / governing the origin and development of the planets, also including the Earth, which is not only scientific, but also of great practical significance. /45

Exploration of space, the problems of exploitation of outer space, and the astronautical, scientific-technological problems posed demand a completely new approach to their accomplishment. The technological solutions found in this connection are already finding application in many fields of the national economy. The construction of rockets, for example, required the creation of basically new materials, capable of withstanding ultralow and ultrahigh temperatures, resistant to changing loads, vibrations, sharp changes in stress. Such materials were created and have found wide application in terrestrial technology, in particular in fields connected with plasma processes. Limitation of weight and overall size of instruments - a necessary condition for successful conduct of explorations in the cosmos - has turned out to be of great influence for progress in the area of microminiaturization of technical equipment in general, and especially in the field of electronics and computer technology.

As we have already mentioned in a number of previously published papers (some of their material has been used in this article), the solution of problems connected with penetration into the depths of space has expedited the tempo of the improvement of automatic control systems, radio-television apparatus, and rapid electronic machines. Cosmonautics gave impetus to the development of new directions in cybernetics.

Space exploration and human flight into space promoted completely new, exceptionally high requirements concerning the reliability of rocket-space systems. The solution of complicated problems of ensuring high reliability of systems and their elements was demanded, taking into account minimum weight and overall size. In this connection, there began intensive development of a science of reliability. The principles of constructing highly reliable elements from elements of relatively low reliability, the principles of majority logic, systems of "voting" according to the rule "two out of three", and many other schemes were worked out which make it possible to obtain trouble-free performance in complicated multi-element systems. These principles, which were verified during the building and testing of rocket-space systems, just as were also the mathematical methods for evaluating the reliability of complex systems, have also found wide application in other fields of technology.

Many instruments, sensing elements and elements of automatic devices developed for the purpose of space exploration and rocket technology are already finding application in various fields of the national economy. For example, ultrasensitive magnetometers, created for the measurement of magnetic fields in outer space, are being used successfully in geophysics, geological prospecting, and even in archeology where they make it possible to determine very weak anomalies in the magnetic field of the earth and simplify the search for useful minerals and the remains of the material culture of ancient man. To a lesser extent than in other branches of science and technology, medicine and biology are indebted to space research. Clinics have at their disposal many instruments which were made for the purposes of space medicine.

The concentration of the efforts of the best specialists in each field for the purpose of resolving questions posed in the exploration of space, the atmosphere of creative search,

which was usually generated during the fulfillment of such tasks, not only ensured the solution of the problems raised, but also was a powerful stimulus to the progress of science and technology generally.

The working out of the problems of space exploration and the creation of technological equipment necessary for their accomplishment lead unquestionably to a heightened level of development of science and technology in the country, to improved qualifications of scientific and technological personnel. One may say truthfully that the exploration of space is an epoch in the development of science generally, in the development of the national economy, economics and culture, and in the social progress of mankind.

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